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Run-off and Mean Flow of Some Texas Streams

BY

T. U. TAYLOR

Published by the University six times a month and entered as second-class mail matter at the postoffice at AUSTIN, TEXAS

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The benefits of education and of useful knowledge, generally diffused through a community, are essential to the preservation of a free government.

Sam Houston.

Cultivated mind is the guardian genius of democracy. . . . It is the only dictator that freemen acknowledge and the only security that freemen desire.

Mirabeau B. Lamar.

RUN-OFF AND MEAN FLOW OF SOME TEXAS STREAMS.

BY T. U. TAYLOR, M. C. E.

The run-off from any water shed in the west depends upon the following factors:

1. Size of catchment area of water shed.
2. Mean Rainfall.
3. Regularity of the Flow.
4. Amount lost by seepage.
5. Amount used for Irrigation.

The area of the water shed can be ascertained with a reasonable degree of accuracy, and the regularity of flow can be ascertained by the construction of hydrographs based upon daily records of gauge heights and flow measurements. These can only be obtained by establishing gauging stations with observations daily upon the stage of the height of the river and by taking a sufficient number of measurements to establish or determine a rating curve or rating table.

The regularity of the flow, the mean flow per day, the mean monthly flow, and the mean annual flow, are data that can be obtained only by careful observations and measurements for the station and stream concerned. The writer for the last eighteen years has made observations of measurements upon the Colorado river at Austin, Texas, and on many other rivers of Texas since 1896. Measurements have been taken on the Colorado at Austin and at Columbus, Texas, on the Brazos river at Waco, and on the Trinity at Dallas and Riverside, Texas.

The results of these observations and measurements are given in the tables that follow. Each year required 365 gauge height readings, and to obtain the mean daily discharge of the water in second-feet, a rating curve or rating table was generally obtained by visiting the station at its highest flood, and then taking systematic measurements by current meters as the level of the water fell. Each station required 365 field observations for gauge heights and then 365 observations again to translate these gauge heights readings by use of the rating table into daily discharges. After the daily discharges were obtained the

gross sum of the mean daily discharge for the month were added and the mean average discharge per second for the month and year was obtained. Thus each year required over 1095 observations. The Colorado at Austin for the last eighteen years required the handling of over 19,500 separate flow or gauge height records, while the station at Columbus for the years covered required 10,950 operations. The Brazos at Waco required over 16,300 records, the Trinity at Dallas over 9,950, the Trinity at Riverside over 12,000 records. Thus the three rivers and the five stations reported on in the following tables required the handling of over 68,000 records and operations. The writer has been personally through all of these records and has had them verified, but the work has spun out over many years, "watching and waiting."

The mean rainfalls on the water sheds for each month were obtained from the mean rainfalls of the rainfall stations distributed over the water shed. Where a rainfall station was on the border of a water shed it was sometimes used to obtain the mean rainfall on its own water shed and the one adjoining. The mean rainfall on the 37,000 square miles, the water shed above Austin, were obtained from the rainfall stations at Abilene, Austin, Ballinger, Big Spring, Brownwood, Coleman, Colorado, Fairland, Fredericksburg, Junction, Lampasas, Llano, Menardville, San Angelo, and San Saba. The stations used to obtain the mean rainfall on 40,000 square miles, the water shed above Columbus, included the fifteen stations mentioned above and also Columbus and La Grange. To obtain the mean rainfall on the water shed of the Brazos above Waco, rainfall data were obtained from Abilene, Albany, Claytonville, Dublin, Graham, Haskell, Kopperl, Mt. Blanco, Panter, Plainview, and Waco, making a total of eleven stations. The mean rainfall on the water shed of the Trinity above Dallas was obtained from Dallas, Fort Worth, Gainesville, and Weatherford. The mean rainfall on the water shed above Riverside was obtained from the four stations mentioned above and from the following stations: Corsicana, Huntsville, Palestine, and Waxahachie. A total of 216 monthly records were used on the watershed of the Colorado for rainfall data, and a total of fifteen stations for each month would make 3240 monthly rainfall records that were handled to obtain the mean rainfall data. A period of 180

months of rainfall data was covered in the records of the Brazos at Waco. The eleven stations would give 1980 records for the Brazos. A total period of ten years or 120 months were covered on the water shed above Columbus. For the 17 rainfall stations above Columbus would give 2040 rainfall records for this station. In the same way 1980 rainfall records were used on the water shed of the Brazos above Waco, 480 records on the water shed of the Trinity above Dallas and 1056 on the water shed of the Trinity above Riverside, making a total of practically 8,800 rainfall records.

In the work of calculation of the run-off, 648 separate calculations had to be performed to ascertain the run-off in inches. A like number of calculations had to be performed to obtain the per cent of run-off, or practically 1300 calculations were performed after the mean rainfall and mean flow for the months given were recorded and tabulated. Checking these results required the same number of calculations.

It will be observed that the present run-off of the Trinity at Riverside is much greater than that at any other station. The Colorado is very low in percentages on account of the fact that possibly one-third of its drainage reaches into the staked plains, and it is a rare occurrence when any of the water that falls along the Texas and Pacific Railway near the corner of New Mexico reaches Austin. The Brazos also reaches up into the plains country where the rainfall is slight and the ground thirsty and generally ready to drink up an ordinary rainfall. In the case of the Trinity at Riverside, the percents of run-off are much greater than those at Austin or Waco. This is on account of the fact that the Trinity for many miles above Riverside, in fact nearly all the way from Dallas, passes through a wooded country that is somewhat even in its topography. The result is that the leaves act as a mattress, serve to hold the moisture and the soil does not become so dry and thirsty. Generally there is a better "season" in the ground in East Texas than in the more westerly portions of the state.

Where the water shed is not long drawn out and is located entirely in a canyon or mountainous section, we may expect much greater run-offs than can be obtained for rivers of greater length traversing wholly, or in part, flat sections of country. One thing that makes the per cent of run-offs of the Colorado

at Austin small or low, is the fact that a large section of the water shed area is in the staked plains or in reasonably flat sections of country from Ballinger west and northwest. The run-offs of the canyon section of the Colorado would be in excess of those given in the table. The run-off of the Guadalupe above New Braunfels would be much greater than that of a river of equal water shed area, and equal rainfall located in a flatter or agricultural section.

In the Medina water shed we can legitimately expect a run-off much in excess of that of the Colorado for equal rainfalls on account of the fact that the water shed above the Medina Dam is located in the Edwards Plateau, which is not only hilly but largely wooded or grazing, a relatively small per cent of which is agricultural.

CALCULATIONS RUN-OFF IN INCHES.

Let X=the depth of rainfall in inches on the whole water shed that would give the mean annual flow at a station on the assumption that none of it was lost by seepage, evaporation, irrigation or otherwise.

A=Area of the water shed in square miles.

Q=Mean discharge in cu. ft. per second.

Then for a year of 365 days, we have:

$$\frac{X \times 640}{12} \quad A \times 840 \times 9 = 30 \times 24 \times 365 \times Q \times 60$$

Hence:

$$X = 3285\ Q \div 242\ A$$

Then for a year of 366 days, we have:

$$X = 3294\ Q \div 242\ A$$

For the Colorado river above Austin, we have:

$$A = 37{,}000.$$

Substituting, we have the equation for run-off in inches:

$$X = Q \div 2726$$

Then for a year of 366 days, we have:

$$X = Q \div 2718$$

The drainage area of the Brazos above Waco is 30,800 sq mi.

Hence for a year of 365 days, we have:

$$X = 3285 \quad Q \div 242 \times 30{,}800 = Q \div 2269$$

For a year of 366 days, we have:

$X=3294\ Q\div 242\times 30{,}800=Q\div 2263$

The drainage area of the Trinity above Dallas has an area of 5950 sq. mi.

For a year of 365 days, we have:

$X=Q\div 438$

For a year of 366 days, we have:

$X=Q\div 437$

The area of the water shed of the Trinity above Riverside is 16,000 sq. mi.

For a year of 365 days, we have:

$X=Q\div 1179$

For a year of 366 days, we have:

$X=Q\div 1176$

ANNUAL RUN-OFF DIVISOR

Station	River	Run-off divisor for a year of		Area of water shed in square miles
		365 days	366 days	
Austin	Colorado	2726	2718	37,000
Columbus	Colorado	2947	2938	40,000
Waco	Brazos	2269	2263	30,800
Dallas	Trinity	438	437	5,950
Riverside	Trinity	1179	1176	16,000

MONTHLY RUN-OFF.

Let Y=the depth of rainfall in inches on the whole water shed that would give the mean monthly flow at a station on the assumption that none of it was lost by seepage, evaporation, irrigation or otherwise.

A=Area of the water shed in square miles.

Q=Mean discharge in cu. ft. per second.

Then for a month of 31 days, we have:

$Y\times 640\ A\times 4840\times 9=60\times 60\times 24\times 31\ Q$

Hence:

$Y=279\ Q\div 242\ A$

Then for a month of 30 days,

$Y=270\ Q\div 242\ A$

For a month of 29 days,

$Y=261\ Q\div 242\ A$

For a month of 28 days,

$Y=252\ Q\div 242\ A$

For the Colorado at Austin,
A=37,000 square miles.

Hence we have:
31 days in month, Y=Q÷32,100
30 days in month, Y=Q÷33,160
29 days in month, Y=Q÷34,300
28 days in month, Y=Q÷35,500

The numbers, 32,100, 33,160, etc., are numbers called the Run-off Divisors, that is, the "Run-off Divisor" is the number by which you divide the mean monthly flow to get the run-off in inches.

To obtain the run-off in inches for any month divide by the Run-off Divisor in the table below.

Station	River	Run-of divisor for month of			
		31 days	30 days	29 days	28 days
Austin	Colorado	32100	33160	34300	35500
Columbus	Colorado	34700	35800	37100	38400
Waco	Brazos	27074	27976	28560	29070
Dallas	Trinity	5121	5329	5713	5518
Riverside	Trinity	13878	14320	14900	15420

In the following tables "R. F." means the mean or average rainfall in inches of depth on the water shed. "Flow" means the mean flow or discharge in cubic feet per second for the period mentioned. "R. O." means the depth in inches that flow past the station would cover the water shed. "P. C. R. O." means the per cent that the run-off is of the rainfall for the month or year concerned.

Colorado River at Austin, Texas.

Area Water Shed=37,000 square miles.

Year		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	An-nual
1896	R. F.	3.16	2.50	.59	2.63	.70	1.16	2.84	1.90	5.22	5.06	.26	1.97	27.86
1896	Flow	920	3900	1660	2500	590	150	1900	478	1890	4600	1400	1690	1630
1896	R. O.	.029	.123	.052	.072	.019	.005	.060	.015	.059	.145	.044	.053	.600
1896	PCRO	.91	4.92	.88	2.74	2.70	.43	2.11	.79	1.16	2.86	16.95	2.68	2.154
1897	R. F.	1.70	.07	2.86	1.70	3.49	2.45	.96	2.87	2.47	2.75	.09	1.20	22.63
1897	Flow	1950	850	1750	1900	3320	3200	570	1000	800	780	300	1310	1390
1897	R. O.	.061	.027	.055	.059	.142	.105	.018	.031	.025	.024	.009	.043	.510
1897	PCRO	3.58	38.57	1.93	3.46	4.05	4.28	1.88	1.08	1.01	.87	10.	3.59	2.254
1898	R. F.	1.06	.66	1.17	3.36	2.80	6.86	2.03	2.09	1.67	.30	1.40	1.95	25.37
1898	Flow	200	400	235	1350	930	3270	1300	700	850	280	260	200	1170
1898	R. O.	.006	.013	.007	.042	.029	.102	.041	.022	.027	.009	.008	.006	.429
1898	PCRO	.57	1.97	.60	1.25	1.03	1.49	1.99	1.05	1.62	3.00	.57	.31	1.691
1899	R. F.	.40	.15	.12	2.98	3.55	6.59	1.52	.17	1.14	2.74	2.47	3.46	26.36
1899	Flow	200	150	150	130	3200	6270	1080	260	280	200	1480	2750	1740
1899	R. O.	.006	.005	.005	.004	.101	.195	.034	.008	.009	.006	.046	.086	.639
1899	PCRO	1.50	3.33	4.17	.13	2.82	2.96	2.25	4.71	.79	.24	1.85	2.48	2.424
1900	R. F.	1.79	.39	3.26	8.41	5.60	.66	3.60	2.57	6.05	3.52	1.52	.98	37.32
1900	Flow	350	585	330	18800	8100	1800	2410	1980	8450	4870	2700	1380	4380
1900	R. O.	.011	.018	.010	.594	.254	.057	.076	.062	.266	.156	.085	.043	1.608
1900	PCRO	.61	4.62	.31	7.08	4.51	8.63	2.11	2.41	4.40	4.41	5.61	4.38	4.309
1901	R. F.	.27	1.37	.78	1.12	3.20	.62	2.36	.85	2.83	.69	1.51	.29	16.10
1901	Flow	1240	1120	910	890	1330	370	1400	463	1470	490	815	480	1040
1901	R. O.	.039	.035	.029	.028	.042	.011	.044	.015	.046	.015	.026	.015	.381
1901	PCRO	14.44	2.55	3.72	2.52	1.32	1.78	1.87	1.77	1.65	2.19	1.72	5.17	2.366
1902	R. F.	.70	.46	1.25	1.61	4.27	1.37	6.25	.16	2.93	1.58	4.64	1.45	27.66
1902	Flow	480	483	732	1711	3052	383	7148	2527	1503	1019	5622	1230	2224
1902	R. O.	.015	.015	.013	.054	.095	.012	.224	.079	.047	.032	.176	.038	.816
1902	PCRO	2.14	3.26	1.84	3.36	2.17	.87	3.58	49.38	1.60	2.03	3.78	2.63	2.950
1903	R. F.	2.00	4.31	1.35	.58	2.22	3.15	2.63	1.38	3.98	1.06	.01	.32	23.64
1903	Flow	1276	5066	4854	2678	2382	2279	1404	801	763	4222	439	320	2157
1903	R. O.	.040	.159	.153	.085	.075	.071	.044	.026	.025	.139	.014	.010	.792
1903	PCRO	2.00	3.70	4.55	14.68	3.38	2.26	1.78	1.89	.63	13.45	.140	3.13	5.350
1904	R. F.	.50	1.63	.32	2.06	4.18	3.50	1.79	1.69	3.86	2.56	.50	.79	25.41
1904	Flow	330	558	394	661	2300	6904	2311	843	2254	1129	466	376	1599
1904	R. O.	.010	.018	.012	.021	.072	.212	.073	.026	.071	.035	.015	.012	.587
1904	PCRO	2.00	1.11	3.75	1.02	1.72	6.26	4.07	5.39	1.84	1.37	3.00	1.53	2.310
1905	R. F.	.71	1.51	3.07	5.00	3.69	2.45	2.54	.98	1.91	2.75	1.67	1.47	28.09
1905	Flow	290	335	1401	6554	6267	1404	1949	755	483	8089	505	299	1918
1905	R. O.	.009	.011	.044	.206	.197	.024	.061	.024	.015	.250	.016	.009	.704
1905	PCRO	1.27	.73	1.43	4.12	5.34	.98	2.41	2.43	.78	9.09	.95	.61	2.506
1906	R. F.	.42	.71	1.03	2.57	3.05	2.81	4.35	5.73	2.78	1.11	1.78	1.37	27.84
1906	Flow	217	247	273	912	1250	3350	6320	12600	9650	511	399	999	3060
1906	R. O.	.007	.008	.009	.029	.039	.105	.194	.396	.302	.006	.003	.031	1.123
1906	PCRO	1.67	1.13	.87	1.13	1.28	3.73	4.56	6.28	10.86	.54	.17	2.26	4.034
1907	R. F.	.46	3.30	1.10	.77	3.68	1.66	3.62	.47	1.26	5.58	4.30	.66	24.33
1907	Flow	217	225	203	145	3400	3100	4680	266	156	3480	3920	949	1740
1907	R. O.	.007	.007	.006	.005	.107	.097	.145	.008	.005	.109	.123	.030	.639
1907	PCRO	1.52	.21	.55	.65	2.93	5.86	4.01	1.70	.40	1.95	2.86	4.54	2.629
1908	R. F.	.47	1.31	1.56	5.32	5.83	.60	2.48	2.37	2.77	1.82	1.94	.40	26.89
1908	Flow	515	885	589	9970	11100	2070	2030	1580	1610	1190	367	566	2710
1908	R. O.	.016	.028	.018	.312	.348	.063	.063	.049	.050	.038	.102	.018	1.005
1908	PCRO	3.42	2.14	1.15	5.87	5.96	10.50	2.52	2.12	1.81	2.09	.62	4.50	3.741
1909	R. F.	.11	.14	.72	1.09	2.61	3.07	2.02	1.19	1.43	2.34	1.27	1.18	18.36
1909	Flow	350	251	188	349	3180	4520	3350	1270	1160	2610	768	2120	1690
1909	R. O.	.011	.008	.006	.001	.100	.142	.105	.040	.036	.082	.024	.066	.620
1909	PCRO	10.00	5.72	.83	1.01	3.83	4.63	5.24	3.36	2.54	3.53	1.06	5.59	3.377

COLORADO RIVER AT AUSTIN, TEXAS.—*Continued.*

Year		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	An-nual
1910	R. F.	.32	.68	.41	2.40	2.30	.99	.46	.65	1.86	2.58	.67	1.19	16.64
1910	Flow	298	417	263	3840	2090	238	444	130	1770	488	195	242	865
1910	R. O.	.009	.013	.008	.121	.066	.007	.014	.004	.056	.015	.006	.008	.318
1910	PCRO	2.84	1.91	1.96	5.04	2.88	.71	3.22	.61	3.01	.58	.90	.67	1.911
1911	R. F.	.33	3.01	1.15	4.47	1.14	.54	2.94	2.62	1.76	1.75	.85	3.30	24.14
1911	Flow	208	3427	484	3234	1507	312	1702	1270	4846	368	178	1205	1540
1911	R. O.	.006	.108	.014	.102	.047	.010	.053	.040	.151	.012	.006	.038	.565
1911	PCRO	1.82	3.59	1.22	2.28	4.12	1.85	1.80	1.55	8.57	.69	.71	1.15	2.343
1912	R. F.	.04	1.83	1.67	1.96	1.66	2.48	.72	1.49	.78	2.15	1.45	1.57	17.90
1912	Flow	390	465	630	701	968	1090	234	601	345	1007	236	405	592
1912	R. O.	.012	.005	.019	.022	.031	.033	.007	.019	.011	.031	.008	.013	.217
1912	PCRO	30.02	.73	1.18	1.12	1.87	1.33	.97	1.28	1.41	4.44	.55	.83	1.212
1913	R. F.	1.07	1.32	.90	1.84	3.22	3.47	.83	1.46	3.48	4.71	6.52	5.26	34.80
1913	Flow	378	378	320	453	3978	2230	1639	422	1748	6196	8996	27350	4560
1913	R. O.	.012	.012	.010	.014	.125	.070	.051	.013	.055	.195	.281	.858	1.694
1913	PCRO	.71	.91	1.11	.76	3.88	2.01	6.15	.89	1.58	4.15	4.33	16.31	4.869
Mean	R. F.	.86	1.42	1.31	2.76	3.18	2.44	2.43	1.70	2.62	2.50	1.89	1.61	25.07
Mean	Flow	545	1093	855	3140	3270	2380	2326	1552	2224	2310	1615	2437	2001
Mean	R. O.	.017	.032	.027	.102	.104	.072	.073	.049	.069	.072	.048	.076	.736
Mean	PCRO	1.98	2.26	2.06	3.70	3.26	2.86	3.00	2.88	2.56	2.88	2.54	4.72	2.913

COLORADO RIVER AT COLUMBUS, TEXAS.

Area Water Shed=40,000 square miles.

Year		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	An-nual
1904	R. F.	.48	1.74	.30	2.16	4.28	3.44	1.88	1.58	3.88	2.72	.56	.95	25.41
1904	Flow	699	840	587	1046	5572	5627	2494	1965	2705	2102	1396	1664	2225
1904	R. O.	.020	.023	.017	.029	.160	.156	.072	.056	.075	.061	.039	.048	.757
1904	PCRO	4.16	1.32	5.67	1.34	3.57	4.53	3.71	3.53	1.81	2.22	6.96	5.01	2.978
1905	R. F.	.65	1.63	3.95	5.18	3.84	2.64	2.55	.98	1.87	2.82	1.92	1.60	28.09
1905	Flow	895	1044	4115	6775	11830	4194	3303	2166	1366	1622	1611	1377	3358
1905	R. O.	.026	.028	.182	.188	.341	.116	.095	.062	.038	.046	.044	.040	1.139
1905	PCRO	4.00	1.72	2.95	3.99	8.79	4.39	3.71	6.34	2.02	1.64	2.28	2.50	4.055
1906	R. F.	.42	.71	1.03	2.57	3.05	2.81	4.35	5.73	2.78	1.11	1.78	1.37	27.84
1906	Flow	1180	1890	1300	1220	1570	3780	3080	9640	4430	1800	1400	1420	2730
1906	R. O.	.034	.051	.037	.039	.045	.105	.088	.272	.122	.052	.039	.041	.926
1906	PCRO	8.08	7.18	3.58	1.44	1.47	3.72	2.01	4.91	4.38	4.67	2.18	2.98	3.326
1907	R. F.	.52	.57	1.19	.90	3.93	1.67	3.78	.58	1.22	5.80	4.56	.94	24.33
1907	Flow	1190	1260	1130	951	5630	5130	4210	1260	514	4010	8960	2720	3090
1907	R. C.	.034	.039	.033	.027	.162	.014	.121	.035	.014	.111	.250	.079	1.049
1907	PCRO	6.53	6.84	1.74	3.00	4.13	.84	3.21	6.03	1.15	1.92	5.48	8.40	4.318
1908	R. F.	.57	1.66	1.54	5.34	5.57	1.20	2.64	2.34	2.79	1.75	2.16	.58	26.89
1908	Flow	1060	2830	1200	9190	12500	4060	2520	1920	1770	1410	1120	1120	3400
1908	R. O.	.031	.076	.034	.253	.360	.113	.072	.055	.049	.041	.031	.032	1.157
1908	PCRO	5.42	4.57	2.21	4.74	6.44	9.43	2.96	2.35	1.76	1.49	1.44	5.52	4.306
1909	R. F.	.09	.26	.69	1.21	2.88	2.96	2.49	1.26	1.46	2.36	2.75	1.55	18.36
1909	Flow	924	666	544	656	2050	3620	2560	1620	1050	2020	1950	2570	1690
1909	R. O.	.026	.018	.015	.018	.059	.101	.072	.046	.029	.057	.055	.074	.573
1909	PCRO	28.91	6.92	2.17	1.48	2.04	3.72	2.88	3.65	1.98	2.41	2.00	4.77	2.577
1910	R. F.	.45	.85	2.41	2.41	2.46	1.04	.64	.65	1.94	2.57	.73	1.57	17.32
1910	Flow	931	682	355	3680	2750	906	682	183	1710	954	579	1050	1200
1910	R. O.	.026	.018	.010	.102	.079	.025	.019	.005	.047	.027	.016	.030	.407
1910	PCRO	52.75	2.12	.41	4.22	3.23	2.45	2.96	.77	2.42	1.05	2.19	1.92	2.352
1911	R. F.	.34	3.02	1.46	4.46	1.68	.50	2.96	2.54	1.76	1.97	.98	3.69	25.00
1911	Flow	576	2330	1780	4251	4170	864	1799	1820	4729	1040	715	2418	2209
1911	R. O.	.016	.061	.051	.171	.121	.024	.052	.052	.131	.030	.020	.069	.749
1911	PCRO	4.69	2.03	3.49	2.62	7.19	4.80	1.75	2.02	.75	1.56	2.02	1.87	2.996
1912	R. F.	.09	2.22	1.76	2.14	2.34	2.62	.81	1.66	.77	2.66	1.54	2.34	19.07
1912	Flow	950	1888	1764	1650	2280	2132	792	724	931	1698	796	1310	1458
1912	R. O.	.027	.051	.051	.046	.065	.060	.022	.021	.026	.044	.022	.037	.496
1912	PCRO	30.00	2.28	2.79	2.15	2.78	2.29	2.71	1.26	3.37	1.65	1.43	1.57	2.603
1913	R. F.	1.12	1.56	1.21	1.84	3.01	3.26	.92	1.57	4.20	5.06	6.41	5.80	36.06
1913	Flow	450	1370	1670	398	5960	3096	2522	1017	1899	10085	7348	26851	5280
1913	R. O.	.013	.026	.047	.011	.172	.086	.073	.029	.053	.291	.202	.077	1.792
1913	PCRO	1.16	1.66	2.88	.59	5.71	2.91	7.94	1.84	1.27	5.74	3.17	1.33	4.978
Mean	R. F.	.47	1.42	1.55	2.82	3.30	2.21	2.30	1.89	2.27	2.88	2.34	2.04	24.84
Mean	Flow	886	1480	1444	2982	5431	3341	2396	2231	2110	2675	2587	4250	2664
Mean	R. O.	.025	.039	.041	.083	.156	.093	.069	.064	.059	.077	.072	.122	.905
Mean	PCRO	5.32	2.73	2.62	2.95	5.04	4.20	3.00	3.38	2.61	2.66	3.06	5.92	3.45

Brazos River at Waco, Texas.

Area Water Shed=30,800 square miles.

Year		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1899	R. F.	.54	.23	.11	2.03	3.58	8.05	2.73	.23	1.23	2.52	2.71	2.97	26.94
1899	Flow	205	168	104	264	1610	9727	9680	641	154	990	5741	3060	2732
1899	R. O.	.007	.006	.004	.009	.059	.348	.358	.024	.006	.037	.205	.113	1.205
1899	PCRO	1.29	2.61	1.74	.44	1.65	4.32	13.11	10.43	.49	1.47	7.56	3.81	4.477
1900	R. F.	1.04	.28	1.85	6.65	4.68	2.28	4.00	2.35	7.13	3.44	.56	.46	34.79
1900	Flow	209	746	896	11126	7400	5017	3165	2385	15498	4360	1670	689	4551
1900	R. O.	.007	.025	.033	.397	.273	.179	.117	.088	.554	.161	.059	.025	2.207
1900	PCRO	.67	8.93	1.78	5.97	5.83	7.8	2.92	3.72	7.77	4.67	10.24	5.42	6.350
1901	R. F.	.03	1.83	.96	1.99	4.12	1.43	1.26	1.12	2.52	.95	1.45	.57	17.39
1901	Flow	391	449	305	677	3036	2762	188	540	791	326	286	220	839
1901	R. O.	.014	.015	.011	.024	.112	.098	.007	.020	.028	.012	.010	.008	.370
1901	PCRO	46.7	.80	1.12	1.26	2.74	7.22	.56	1.75	1.15	1.27	.69	1.41	2.129
1902	R. F.	.19	.27	1.60	1.30	4.65	1.29	7.72	.17	2.37	2.45	4.08	1.03	27.07
1902	Flow	84	74	995	1062	4280	2123	12528	2354	1609	1230	4491	1491	2694
1902	R. O.	.003	.002	.037	.038	.158	.076	.462	.087	.058	.045	.161	.055	1.187
1902	PCRO	1.57	.71	2.32	2.93	3.38	5.90	5.94	51.2	2.44	1.84	3.93	5.42	4.389
1903	R. F.	1.62	4.37	1.75	.82	2.10	4.03	2.16	2.06	3.69	1.65	.07	.12	24.44
1903	Flow	1004	5860	6532	1111	662	1580	1440	791	604	3775	501	165	2002
1903	R. O.	.037	.196	.241	.040	.024	.056	.053	.029	.021	.139	.018	.006	.883
1903	PCRO	2.44	4.47	13.38	4.92	1.12	1.39	2.45	1.41	5.69	8.41	25.14	5.00	3.366
1904	R. F.	.85	1.11	.50	1.76	3.63	4.07	1.50	1.98	3.35	3.19	.25	.25	22.64
1904	Flow	115	305	376	528	2245	3341	1697	1757	1128	1922	508	238	1180
1904	R. O.	.004	.010	.014	.019	.083	.119	.063	.065	.041	.071	.018	.008	.521
1904	PCRO	.47	.90	.70	1.08	2.24	2.92	4.20	3.26	1.22	2.27	7.20	3.20	2.301
1905	R. F.	1.09	2.09	4.39	5.91	5.25	3.74	4.75	1.58	2.90	1.22	2.28	2.07	38.25
1905	Flow	388	585	1642	7347	18280	3898	5771	2276	1906	1561	718	931	3775
1905	R. O.	.014	.019	.061	.263	.675	.139	.213	.084	.068	.058	.026	.034	1.664
1905	PCRO	1.28	.91	1.39	4.82	12.85	3.70	4.47	5.27	2.34	4.77	1.14	1.64	4.355
1906	R. F.	.60	1.10	1.21	2.96	3.98	4.08	4.39	4.80	4.24	1.75	2.77	1.13	32.82
1906	Flow	548	733	352	547	3970	8610	3090	4020	3020	1400	640	1270	2350
1906	R. O.	.020	.024	.013	.019	.146	.308	.114	.148	.108	.052	.023	.047	1.036
1906	PCRO	3.33	2.18	1.07	.64	3.66	7.55	2.61	3.07	2.54	2.95	.83	4.16	3.156
1907	R. F.	1.07	.22	1.04	1.17	4.90	2.13	3.36	1.09	.87	4.79	3.18	1.66	25.34
1907	Flow	827	580	557	351	2810	3670	3400	858	376	2560	2590	3440	1850
1907	R. O.	.031	.019	.021	.014	.104	.136	.125	.032	.014	.10	.095	.127	.816
1907	PCRO	2.88	8.62	2.03	1.19	2.13	6.32	3.68	2.93	1.63	2.07	3.07	7.62	3.220
1908	R. F.	.58	1.08	1.38	6.88	6.97	1.36	4.80	2.02	2.75	1.99	2.22	.32	30.63
1908	Flow	1220	1500	1310	19100	22000	3120	1060	777	926	444	218	365	4340
1908	R. O.	.045	.050	.048	.683	.812	.111	.039	.029	.033	.016	.008	.013	1.918
1908	PCRO	7.68	4.57	3.47	9.95	11.64	8.22	.81	1.44	1.20	.81	.36	4.07	6.268
1909	R. F.	.09	.35	.71	.47	2.23	4.36	1.51	2.72	.75	2.48	3.97	1.89	21.63
1909	Flow	32	22	32	27	354	4610	359	1410	113	230	437	7750	866
1909	R. O.	.001	.001	.001	.001	.013	.165	.013	.052	.004	.009	.016	.286	.382
1909	PCRO	1.11	.29	.14	.21	.58	3.77	.86	1.91	.52	.36	.41	15.05	1.768
1910	R. F.	.51	.76	1.26	1.77	3.53	1.51	1.14	1.22	1.48	1.76	.41	1.15	17.24
1910	Flow	114	191	42	1420	3290	620	170	19	616	270	79	56	576
1910	R. O.	.004	.006	.015	.051	.121	.022	.006	.001	.002	.010	.003	.002	.254
1910	PCRO	.81	.78	.12	2.87	3.42	1.45	.53	.08	1.48	.56	.74	.18	1.458
1911	R. F.	.38	3.79	1.19	3.28	.77	.46	4.91	2.90	2.18	1.24	.62	4.28	26.15
1911	Flow	9	1114	241	444	186	37	4030	1720	5169	174	81	2340	1297
1911	R. O.	.000	.037	.009	.016	.007	.001	.149	.064	.185	.006	.003	.086	.572
1911	PCRO	.00	.97	.76	.48	.91	.22	3.05	2.21	8.44	.48	.48	2.06	2.188
1912	R. F.	.01	1.77	2.48	2.11	2.22	2.79	.92	3.28	1.74	1.93	.42	1.37	21.07
1912	Flow	423	577	1144	1026	1150	1409	413	4470	646	1427	240	127	1090
1912	R. O.	.016	.019	.042	.004	.043	.050	.015	.165	.023	.053	.009	.005	.482
1912	PCRO	1.60	10.72	1.68	.19	1.92	1.78	1.63	5.04	1.29	2.75	2.14	.37	2.288

BRAZOS RIVER AT WACO, TEXAS.—*Continued.*

Year		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1913	R. F.	1.01	1.04	1.15	2.28	3.24	3.51	1.14	1.08	4.26	3.28	5.32	4.11	31.98
1913	Flow	87	189	342	791	5190	1973	1528	550	3642	6770	6799	24800	4450
1913	R. O.	.003	.006	.013	.028	.191	.071	.056	.020	.130	.250	.243	.916	1.962
1913	PCRO	.29	.57	1.14	1.22	5.92	2.04	4.88	1.86	3.06	7.62	4.55	22.50	6.135
Mean	R. F.	.64	1.35	1.44	2.76	3.72	3.01	3.09	1.91	2.76	2.31	2.02	1.55	26.56
Mean	Flow	374	870	997	3055	5098	3499	3235	1638	2413	1829	1666	3126	2306
Mean	R. O.	.014	.029	.037	.109	.188	.125	.118	.060	.086	.067	.060	.115	1.031
Mean	PCRO	2.18	2.14	2.58	3.98	5.05	4.16	3.82	3.13	3.12	2.78	2.97	7.42	3.590

Trinity River at Dallas, Texas.

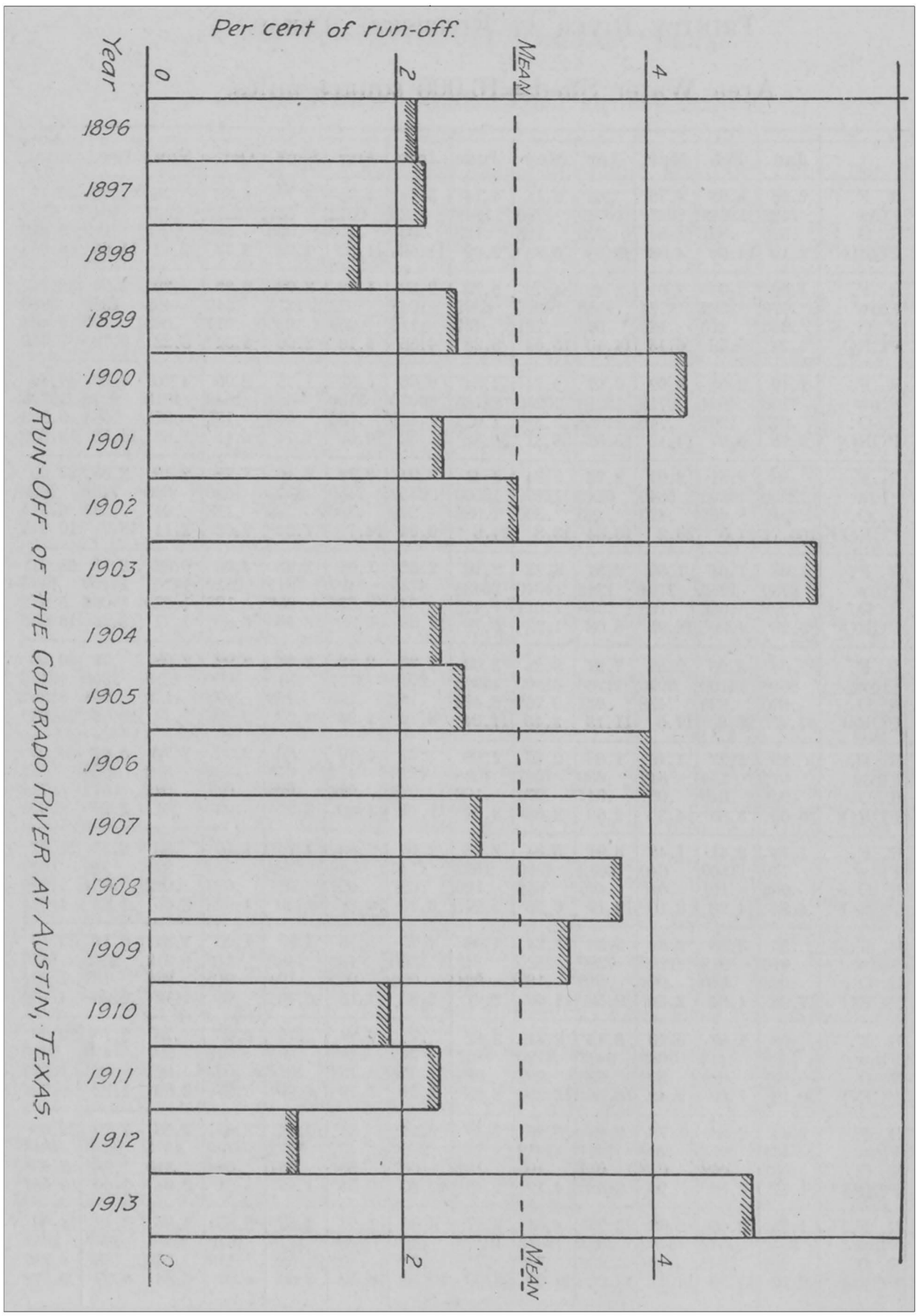
Area Water Shed=5950 square miles.

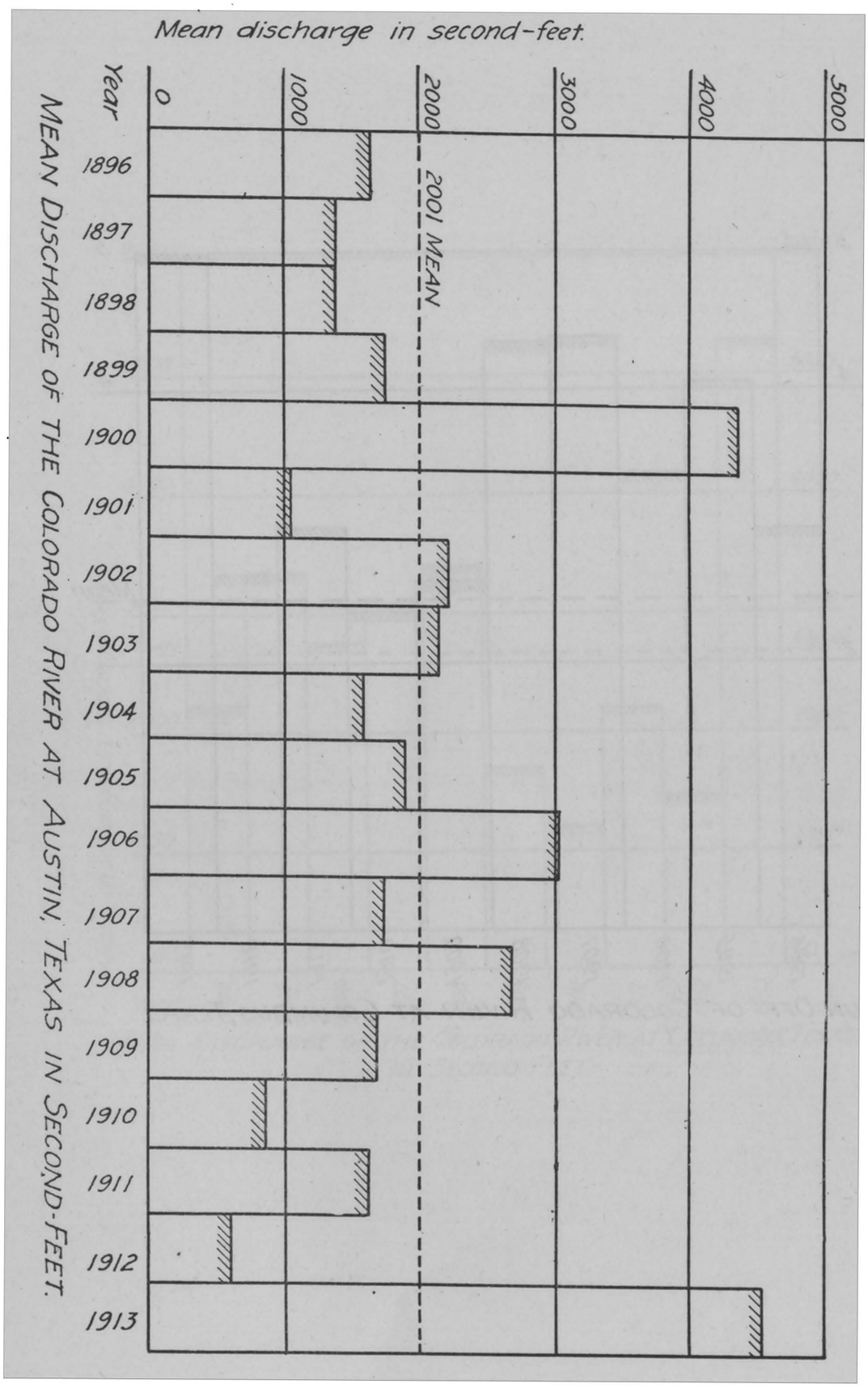
Year		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1904	R. F.	1.38	1.71	2.99	3.09	4.29	6.04	1.32	1.64	2.38	5.34	.09	.48	30.76
1904	Flow	159	163	1080	758	892	1380	195	264	245	228	152	130	470
1904	R. O.	.031	.029	.214	.144	.175	.026	.038	.052	.046	.044	.028	.025	1.076
1904	PCRO	2.23	1.69	7.12	4.66	4.07	.43	2.88	3.16	1.36	.83	31.11	5.21	3.497
1905	R. F.	1.97	2.29	3.94	6.18	6.31	3.81	8.36	1.05	2.05	3.36	3.62	4.15	45.78
1905	Flow	185	242	779	2780	5460	811	3970	340	239	501	1050	1450	1480
1905	R. O.	.036	.042	.154	.521	1.138	.154	.771	.066	.045	.098	.197	.283	3.379
1905	PCRO	1.83	1.84	3.91	8.42	17.95	4.04	9.22	6.28	2.20	2.92	5.46	6.83	7.382
1906	R. F.	1.14	2.18	2.42	3.61	7.42	4.23	4.82	4.19	4.47	1.18	2.00	1.40	39.06
1906	Flow	535	1480	733	993	5370	2690	1600	1830	1510	285	270	332	1470
1906	R. O.	.110	.261	.146	.186	1.100	.505	.312	.356	.284	.056	.051	.065	3.356
1906	PCRO	9.65	11.84	6.03	5.16	14.85	11.94	6.47	8.47	6.35	4.75	2.55	4.64	8.589
1907	R. F.	.90	1.32	1.05	2.43	6.45	1.89	3.42	1.55	1.86	4.23	5.24	2.66	31.49
1907	Flow	344	282	421	315	2246	2769	1003	235	171	1103	972	1364	993
1907	R. O.	.067	.049	.082	.059	.438	.518	.196	.046	.032	.215	.184	.266	2.207
1907	PCRO	7.45	3.72	7.81	2.43	6.81	.277	5.76	3.04	1.74	5.08	3.38	10.00	7.199
1908	R. F.	.98	2.63	2.87	8.50	9.10	4.51	2.85	1.60	3.70	4.07	1.85	.39	42.62
1908	Flow	380	1382	861	9680	1488	4660	1861	487	456	1230	404	552	3068
1908	R. O.	.074	.250	.168	1.813	.291	.874	.362	.095	.085	.241	.075	.108	7.021
1908	PCRO	7.55	9.54	5.85	21.16	3.19	19.35	12.64	5.94	2.27	5.90	4.04	27.64	16.477
1909	R. F.	.27	.44	.88	1.40	1.40	2.93	.18	2.37	1.00	2.60	3.35	3.50	22.81
1909	Flow	254	446	329	310	247	934	901	905	264	562	612	797	554
1909	R. O.	.049	.077	.064	.058	.048	.175	.176	.177	.049	.109	.112	.156	1.264
1909	PCRO	18.12	17.48	7.27	4.14	3.43	5.96	97.68	7.47	4.90	4.18	3.31	4.44	5.546
1910	R. F.	1.26	1.50	.99	3.94	4.47	1.53	2.08	.58	2.21	1.08	.41	1.48	21.51
1910	Flow	235	238	186	843	783	776	940	538	723	466	418	667	571
1910	R. O.	.046	.041	.036	.157	.153	.145	.184	.105	.135	.091	.078	.131	1.304
1910	PCRO	3.66	2.72	3.62	4.01	3.42	9.52	8.85	18.10	6.08	8.43	19.01	8.84	6.069
1911	R. F.	.40	3.86	1.68	2.79	.78	.72	4.82	4.43	2.05	1.58	.83	4.48	28.68
1911	Flow	251	216	196	202	161	144	504	570	120	184	157	134	327
1911	R. O.	.049	.037	.038	.037	.031	.027	.097	.112	.022	.036	.029	.026	.746
1911	PCRO	12.25	.96	2.26	1.33	3.97	3.73	2.04	2.51	1.072	2.26	3.50	.58	2.602
1912	R. F.	.08	1.41	4.91	3.28	2.01	4.81	.74	5.94	.62	1.88	.65	1.81	28.15
1912	Flow	180	164	521	1615	506	935	906	123	180	224	200	183	510
1912	R. O.	.035	.030	.102	.231	.099	.175	.176	.024	.028	.044	.037	.036	1.167
1912	PCRO	4.37	2.13	2.08	7.02	4.82	3.64	23.75	4.04	4.51	2.33	5.68	1.98	4.146
1913	R. F.	2.33	1.09	1.59	2.31	3.46	2.85	2.93	.26	5.75	2.99	6.20	5.34	37.09
1913	Flow	187	185	181	399	867	279	415	179	414	896	1710	6554	997
1913	R. O.	.036	.032	.035	.075	.168	.052	.081	.035	.077	.175	.321	1.282	2.263
1913	PCRO	1.54	2.94	2.20	3.25	4.86	1.82	2.77	13.47	1.34	5.85	5.18	13.39	6.101
Mean	R. F.	1.07	1.84	2.33	3.75	4.57	3.33	3.15	2.36	2.61	2.83	2.42	2.57	32.80
Mean	Flow	271	480	529	1790	1802	1538	1230	547	432	568	595	1216	1044
Mean	R. O.	.053	.087	.106	.336	.351	.285	.228	.107	.081	.112	.112	.236	2.378
Mean	PCRO	4.94	4.72	4.55	8.96	7.67	8.81	7.53	4.54	3.10	3.92	4.58	9.20	6.760

Trinity River at Riverside, Texas.

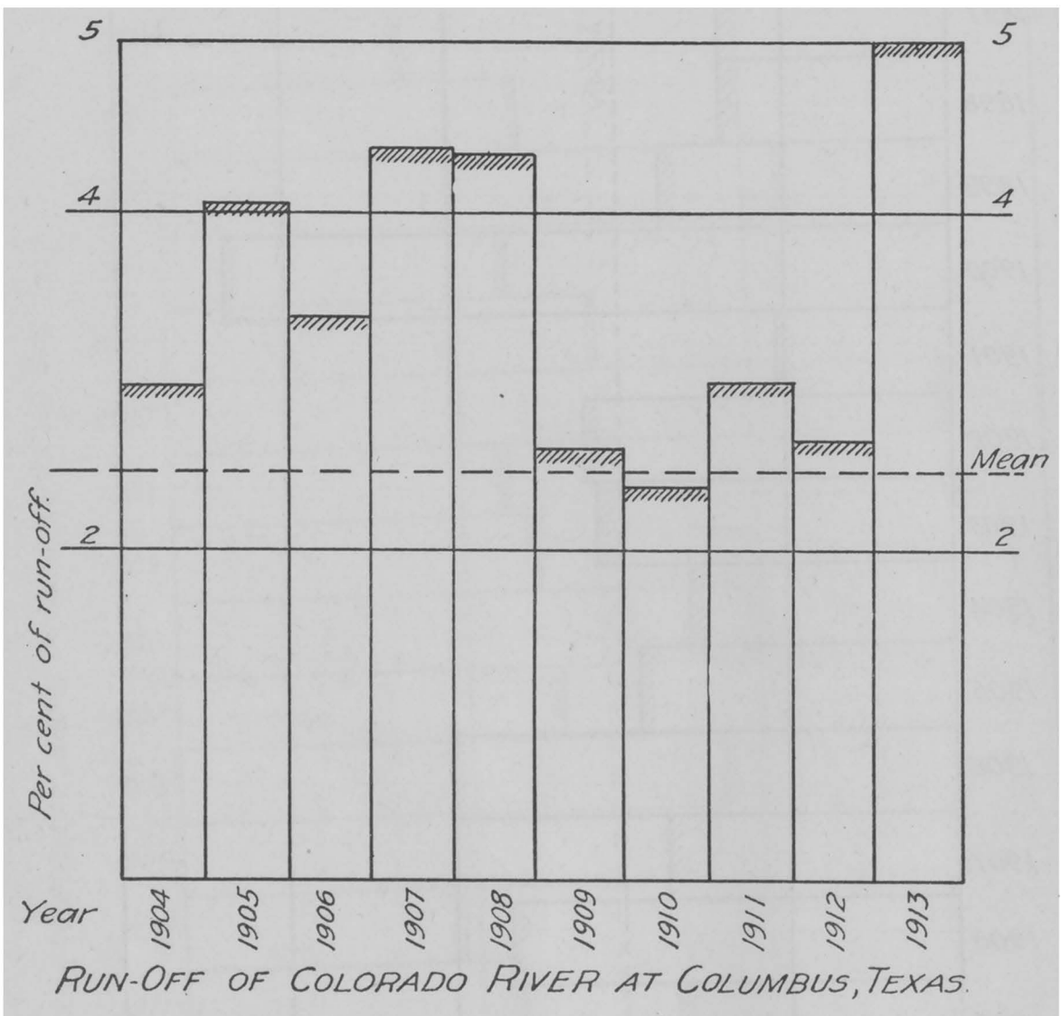
Area Water Shed=16,000 square miles.

Year		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	An-nual
1903	R. F.	2.58	5.83	3.76	.81	2.14	4.14	5.14	1.15	3.77	4.32	.25	1.02	36.47
1903	Flow	7302	13689	25276	10049	1780	1849	8320	6572	537	5219	1031	1642	6897
1903	R. O.	.526	.851	1.84	.723	.128	.133	.60	.475	.039	.376	.074	.119	5.849
1903	PCRO	2.15	14.58	4.88	39.38	6.32	2.99	11.66	41.50	1.03	8.73	29.62	11.66	16.050
1904	R. F.	1.32	2.04	2.01	3.49	4.78	5.29	2.59	1.66	3.02	3.95	.39	1.71	32.24
1904	Flow	779	3232	1724	7185	10090	6272	1648	973	1274	240	462	1389	2936
1904	R. O.	.056	.216	.123	.503	.721	.437	.118	.069	.089	.017	.032	.100	2.488
1904	PCRO	4.24	10.58	6.13	14.40	15.04	8.28	4.55	4.16	2.96	4.31	8.22	5.78	7.750
1905	R. F.	2.19	2.94	5.02	6.97	5.74	4.54	6.66	.83	1.75	2.99	4.10	4.56	47.44
1905	Flow	1108	4064	9716	15310	30260	24180	20070	8136	682	1848	4613	9270	10770
1905	R. O.	.079	.262	.710	1.068	2.196	1.674	1.442	.586	.048	.133	.321	.664	9.123
1905	PCRO	3.78	8.87	14.15	15.32	38.21	36.82	21.32	70.60	2.74	4.44	7.82	14.53	19.256
1906	R. F.	.88	2.41	2.07	2.72	5.84	4.41	3.94	3.73	3.46	1.78	2.19	2.83	37.00
1906	Flow	13200	10300	5840	6240	11200	15500	3450	7450	3530	1650	666	7400	7200
1906	R. O.	.949	.665	.420	.436	.806	1.082	.249	.536	.249	.118	.047	.532	6.011
1906	PCRO	106.71	27.6	20.2	16.04	13.8	24.6	6.34	14.7	7.24	6.62	2.14	18.7	16.241
1907	R. F.	1.08	1.61	1.50	2.81	8.22	2.10	2.52	1.01	2.25	4.66	6.92	3.18	35.91
1907	Flow	3780	1265	2704	1265	14040	20488	4780	497	811	2510	17751	14400	7047
1907	R. O.	.272	.082	.195	.088	1.011	1.426	.344	.036	.057	.182	1.239	1.036	5.972
1907	PCRO	25.20	4.99	12.95	6.68	1.22	6.78	13.65	3.59	2.56	3.88	1.77	3.26	16.635
1908	R. F.	1.08	3.26	2.50	7.27	9.21	3.09	2.25	2.58	3.54	2.92	2.08	.74	40.50
1908	Flow	8610	14100	6070	11766	31600	40966	2740	2721	2319	1008	2318	1308	10416
1908	R. O.	.620	.939	.438	.821	2.262	3.422	.197	.196	.162	.072	.163	.094	8.851
1908	PCRO	57.4	28.8	17.6	11.15	2.45	11.04	8.72	7.55	4.57	2.46	7.74	12.66	21.885
1909	R. F.	.29	1.27	1.42	1.68	2.76	2.98	.77	1.80	.80	2.92	2.72	3.62	24.09
1909	Flow	672	754	842	639	1027	1529	1220	472	370	388	318	996	851
1909	R. O.	.948	.049	.061	.044	.074	.106	.088	.034	.026	.027	.022	.072	.721
1909	PCRO	16.55	3.86	4.35	2.63	2.68	3.54	11.41	1.88	3.25	.92	.81	1.99	2.996
1910	R. F.	1.14	2.41	1.48	3.91	5.34	2.02	2.16	.83	1.76	1.16	.83	3.31	26.32
1910	Flow	770	1560	640	6813	4900	1536	1140	366	392	320	321	746	1529
1910	R. O.	.055	.101	.046	.476	.352	.106	.082	.027	.027	.023	.022	.054	1.296
1910	PCRO	4.83	4.28	3.10	12.17	6.58	5.24	3.79	3.27	1.53	1.96	2.65	1.63	4.924
1911	R. F.	.36	3.58	2.64	5.33	1.24	1.08	4.73	3.16	1.82	1.60	1.34	6.14	33.19
1911	Flow	910	915	1290	7280	2520	343	1320	486	1485	216	213	2540	1630
1911	R. O.	.065	.059	.094	.510	.182	.024	.094	.035	.104	.015	.015	.182	1.381
1911	PCRO	17.05	1.64	2.54	9.58	11.66	2.21	1.99	1.18	6.73	.95	1.12	2.96	4.161
1912	R. F.	.88	1.82	5.39	3.45	2.41	3.87	.77	4.24	.70	2.46	.78	2.70	29.29
1912	Flow	1070	445	7083	9427	4120	1257	745	2240	305	342	301	470	2320
1912	R. O.	.077	.029	.509	.655	.296	.088	.054	.161	.021	.024	.021	.033	1.973
1912	PCRO	20.12	1.60	9.43	18.98	12.29	2.28	7.01	3.79	3.00	.97	2.68	1.22	6.736
1913	R. F.	2.44	2.08	1.78	2.84	3.26	2.44	2.14	.31	6.05	3.64	4.26	7.79	38.05
1913	Flow	431	957	280	1511	1912	758	3660	472	1233	4320	1225	3225	4345
1913	R. O.	.031	.062	.017	.017	.105	.137	.053	.261	.034	.084	.310	.234	3.836
1913	PCRO	1.27	2.59	.96	3.68	4.19	2.16	12.20	10.95	1.39	8.51	2.04	3.02	10.081
Mean	R. F.	1.25	2.66	2.68	3.75	4.64	3.27	3.06	1.94	2.62	2.85	2.35	3.42	34.59
Mean	Flow	3512	4662	5583	7044	10313	10425	4463	2758	1175	1642	2656	3944	5085
Mean	R. O.	.252	.302	.404	.492	.742	.798	.392	.190	.082	.116	.185	.284	4.378
Mean	PCRO	20.16	11.35	14.51	13.02	16.00	22.30	10.52	10.50	3.06	4.07	7.86	8.29	9.572

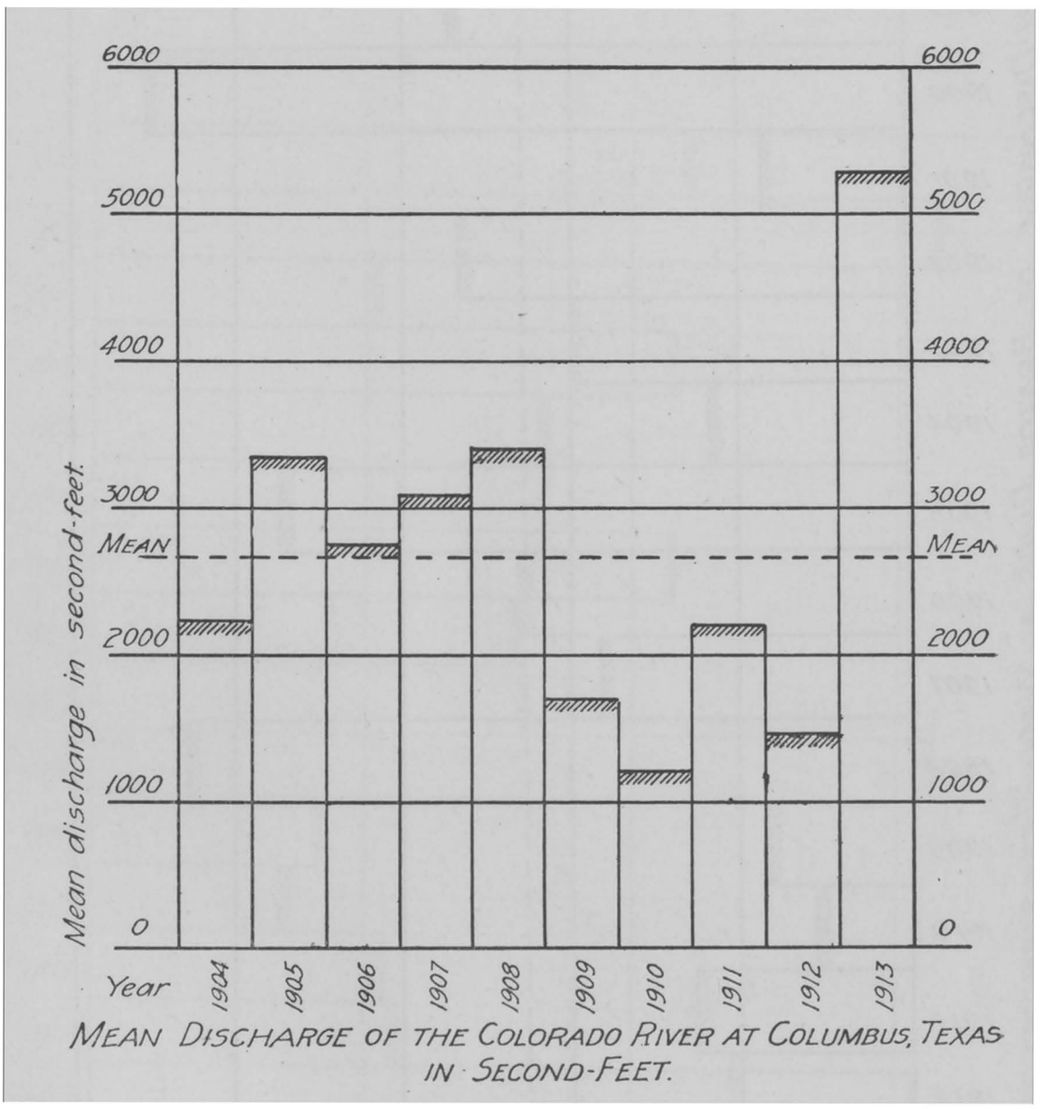

Per cent of run-off.
Year
0
2
MEAN
4
1896
1897
1898
1899
1900
1901
1902
1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
RUN-OFF OF THE COLORADO RIVER AT AUSTIN, TEXAS.



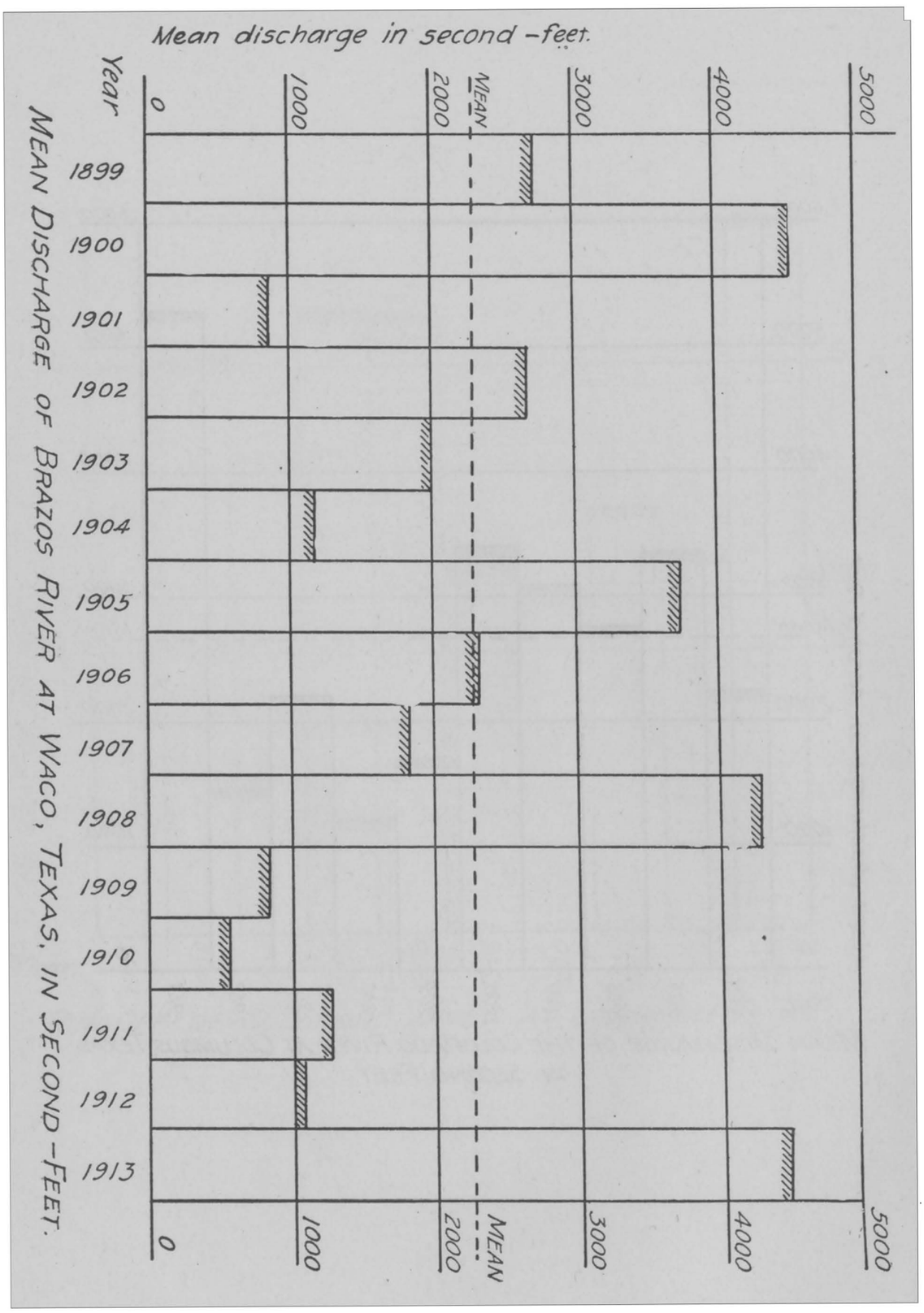
MEAN DISCHARGE OF THE COLORADO RIVER AT AUSTIN, TEXAS IN SECOND-FEET.

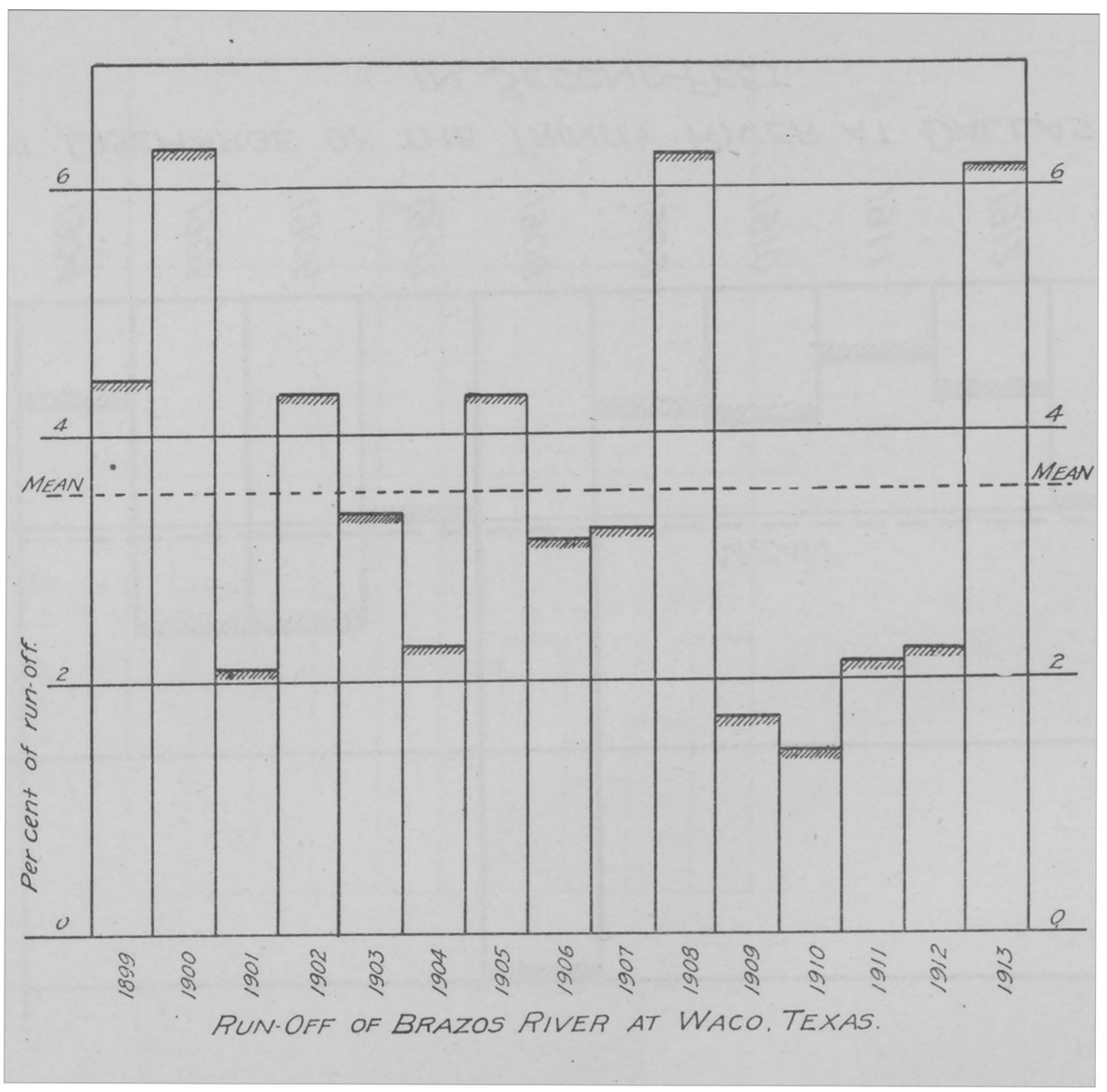


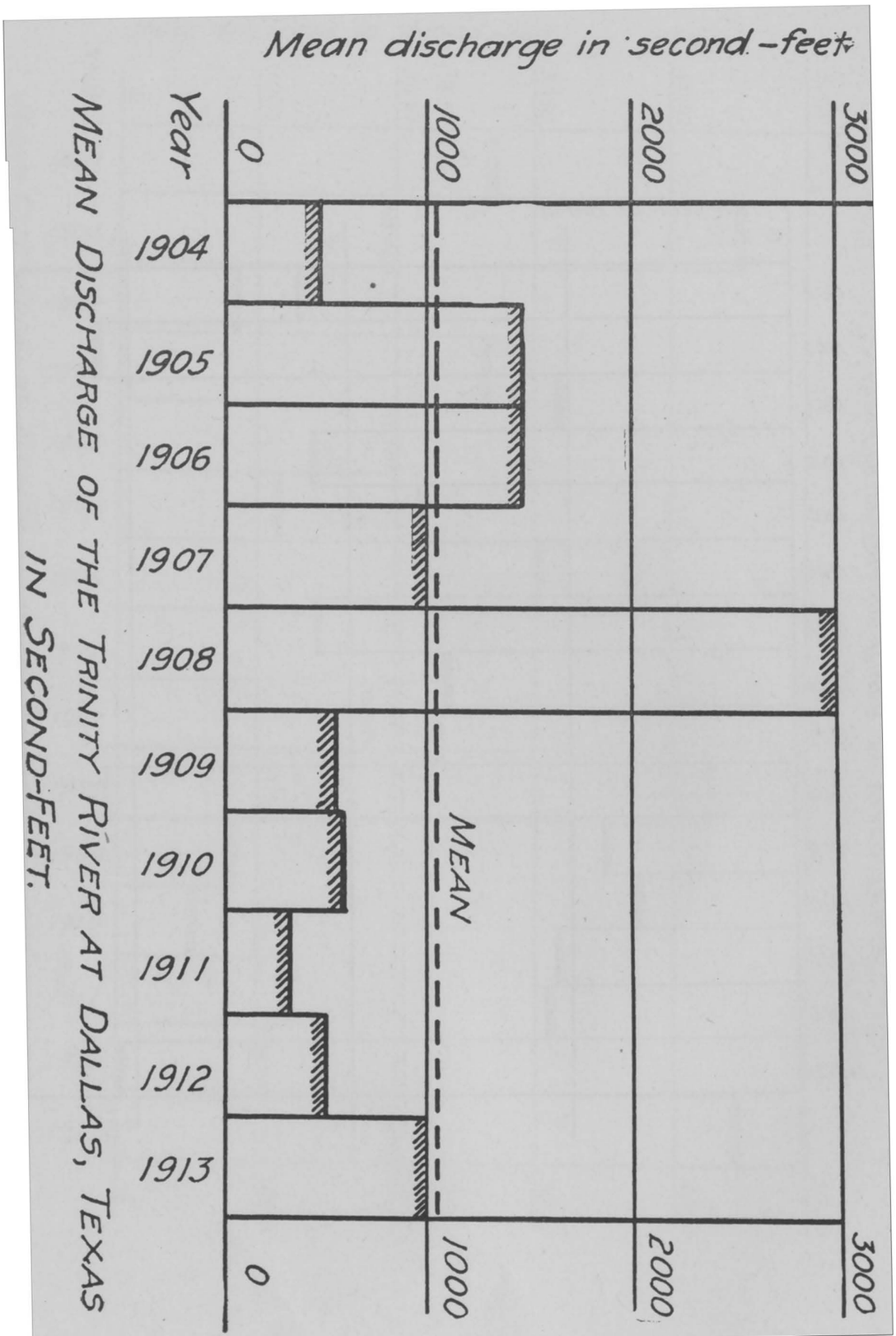
RUN-OFF OF COLORADO RIVER AT COLUMBUS, TEXAS.

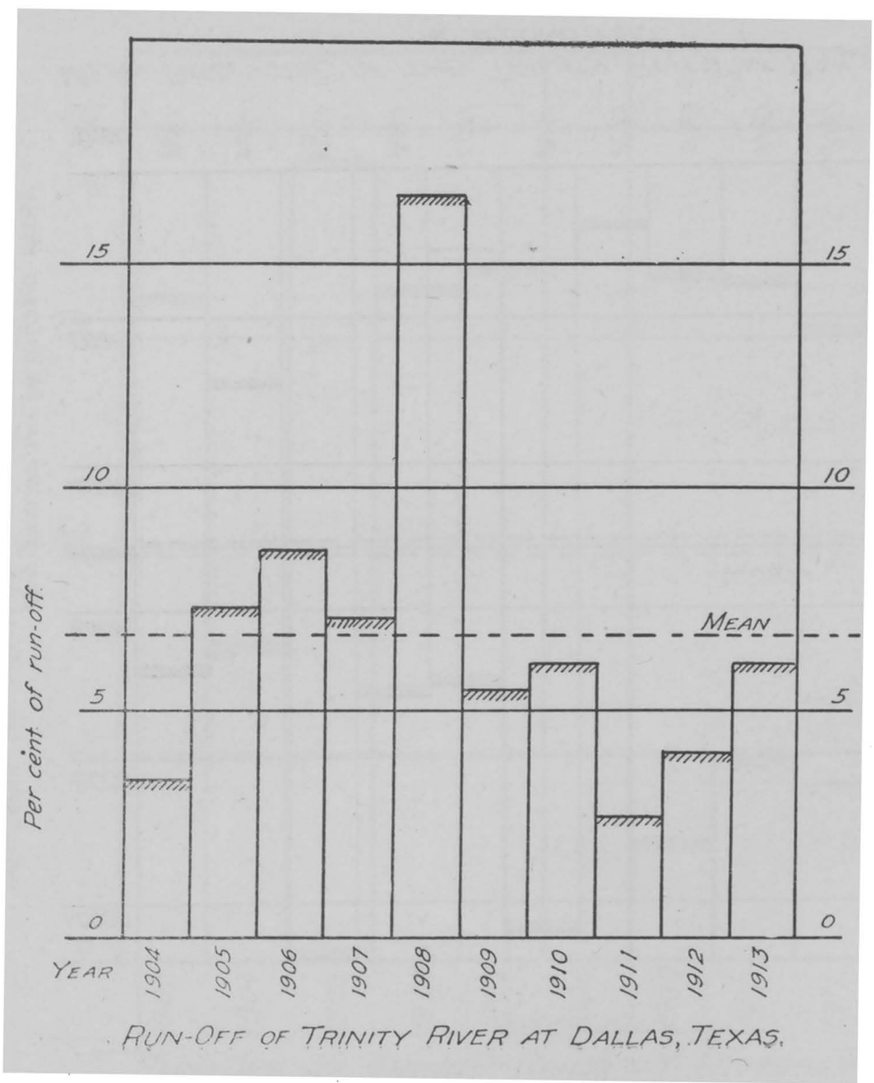


MEAN DISCHARGE OF THE COLORADO RIVER AT COLUMBUS, TEXAS IN SECOND-FEET.

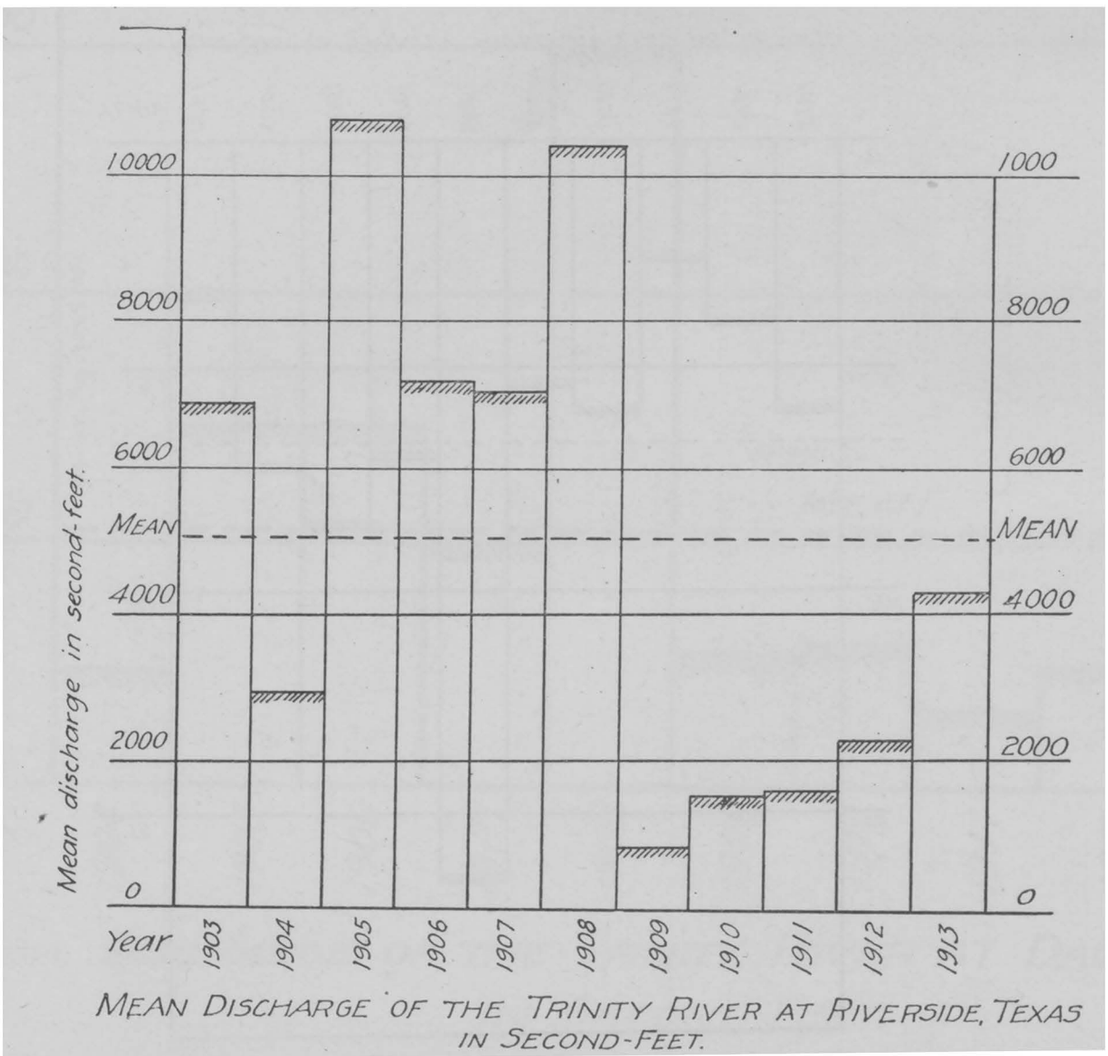

Mean discharge in second-feet.
Year
0
1000
2000
MEAN
3000
4000
5000
1899
1900
1901
1902
1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
MEAN DISCHARGE OF BRAZOS RIVER AT WACO, TEXAS, IN SECOND-FEET.


6
4
MEAN
2
0
Per cent of run-off
1899
1900
1901
1902
1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
RUN-OFF OF BRAZOS RIVER AT WACO, TEXAS.

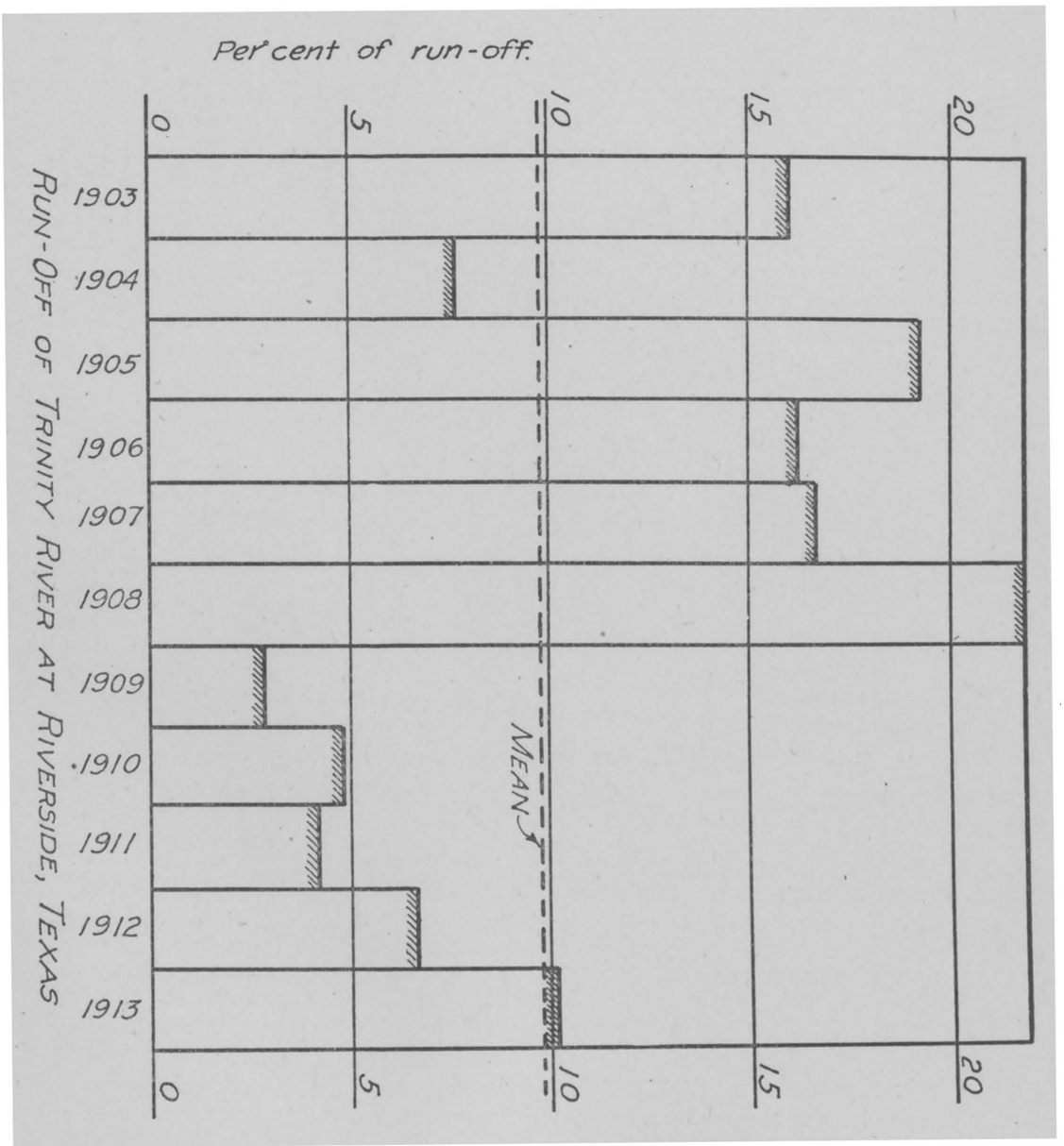

Mean discharge in second-feet
0
1000
2000
3000
Year
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
MEAN
MEAN DISCHARGE OF THE TRINITY RIVER AT DALLAS, TEXAS
IN SECOND-FEET.



RUN-OFF OF TRINITY RIVER AT DALLAS, TEXAS.



MEAN DISCHARGE OF THE TRINITY RIVER AT RIVERSIDE, TEXAS IN SECOND-FEET.


Per cent of run-off.
0
5
10
15
20
1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
MEAN
RUN-OFF OF TRINITY RIVER AT RIVERSIDE, TEXAS